The Application of Solar-Noise Barriers for UK highways and their combined benefits for local government, developers and the wider community

Giles Parker
Managing Director, Sound Barrier Solutions Ltd, United Kingdom

Summary
This presentation considers the design for a hybrid solar / noise barrier scheme for the Swindon A419 that gives optimum noise mitigation for unprotected communities to the west of the carriageway, and also for the proposed Eastern Villages development. By incorporating solar power generation into the eastern design this will provide ongoing revenue from power generation that will potentially cover the cost of the full noise barrier scheme completely. At a total cost of about £3.2 million for 1.7km of absorptive noise barriers to the west of the carriageway and a 2km long solar noise barrier for the eastern villages, the revenue from solar power generation is expected to be £140,000 per annum or a total of £3.5 million over 25 years. For the Eastern Villages, the reduced noise levels could also make available substantially more proposed land for residential development and act as a sustainable power plant for many of the homes.

1. Introduction

The aim of this study was to provide a noise barrier design scheme for the A419 east of Swindon from the Commonhead junction in the south to Blunsdon in the north. This study was carried out to assess the four existing noise fences that had been installed at noise sensitive points along the west side of the carriageway, to determine the need for further noise barriers to 'fill in the gaps' on the west side and to determine the suitability of using combined solar-noise barriers in these locations.

A further aim was to determine the viability and benefit of installing a solar noise barrier on the east side of the carriageway to protect a new proposed "Eastern Villages" housing development and as a means of generating revenue though solar power to pay for the complete noise barrier mitigation scheme.

Where beneficial recommendations were given to replace and upgrade some of the existing noise fences where it was identified that the level of noise mitigation they provide would deteriorate with time due to timber fence degradation.

The assessment was carried out using the predictive computer modelling package Mithra that was calibrated using on site noise measurements and known current and predicted future traffic loadings.

1.1. Existing Western Fences and Gaps

As the A419 has been upgraded to a full speed dual carriageway, the need to provide noise mitigation has grown. At different stages within the last 10 years timber noise fences ranging in height from 2.5 to 3 metres have been installed on the western side to provide noise mitigation between the Commonhead Junction and Blunsdon for existing residential areas. Generally these have been of a basic single-skinned timber reflective design. Some have also been built onto bunds to provide a combined level of mitigation.

The existing fences were of a very thin construction ~ 20mm single skin timber reflective and in the case of the most noise sensitive, St Paul's Drive, the fence was very close to the protected properties. In many cases the house facade first floor windows are above the fence top line with a direct sight line onto the carriageway itself. Whilst this was acoustically a very poor design option there would have been some resistance at the design stage to a higher structure that may block light for residents close to the barrier.

The four existing timber fences at Commonhead, St Paul's Drive, Gifford Road and Boundary Close left obvious gaps where potentially noise barriers could be further utilized at Liden Lagoon, Merlin Way, Watermead and Retingham Way.

1.2. Eastern Villages

The Eastern Villages forms part of the future growth development plan for Swindon. Located on the east side of the A419 carriageway between the Commonhead Junction and the A420 Junction, this land has a 2km frontage onto the A419 southbound carriageway. It is generally at the same height as the verge or 1-2 metres lower and completely exposed to A419 traffic noise.

Any new residential development in this location would require noise mitigation in the form of noise barrier or bund. Put another way, noise barriers can be utilized successfully in order to build houses closer to the carriageway and thus maximize the developable area and subsequent value of the land.

1.3. Benefits of Solar Noise Barriers

Noise barriers indirectly provide large potential surfaces for mounting solar panels for power generation. Since noise barriers are generally built within close proximity to the houses they are protecting, a combined solar noise barrier would also bring a power plant close to potential customers thus providing a dual service and benefit.

Solar noise barriers of sufficient length and surface area provide the potential of ongoing revenue through power generation. Correctly proportioned, this can offset the cost of the noise barrier installation itself giving the potential of free/subsidized noise barrier provision. This can also ensure that the barrier is designed and specified to a higher quality and durability level which in turn reduces ongoing maintenance costs associated with historically thin fence designs.

2. Acoustic Design Criteria

2.1. For Existing Communities (Western)

There is no regulated noise limit associated with the noise experienced by local existing residents due to traffic levels on existing UK highways. If there has been a substantive change to the road design (new road, road widening, re-routing) that might result in a change in traffic noise levels, then the noise impact of this would need to be assessed under the Land Compensation Act to determine entitlement to compensation due to the change.

In this scheme there has been no change to the design only a continual increase in traffic levels. This study is carrying out an assessment of existing properties to the west of the A419. Therefore this assesses the predicted $LA10_{18hr}$ noise level in dBA at the most exposed window façade (generally first floor unless bungalows) which is the parameter considered under the Noise Insulation Regulations.

When considering entitlement for compensation, the Noise Insulation Regulations requires that the the traffic noise level be at least 68dBA $L10_{18hr}$. In this study, this value is used as a guide only since compensation is not being considered and the purpose it to provide noise mitigation for as many properties as practically possible.

2.2. For New Developments (Eastern)

The primary noise limiting factor for new housing developments is the noise criteria given in the World Health Organisation Guidelines for Community Noise. The criteria for noise levels within properties (day or night) can be normally met through offering suitable design options for walls, windows and ventilation. However the criteria for external noise levels in gardens, balconies and amenity spaces can only be met by limiting the area where residential development may be permitted, by incorporating noise barrier designs into the development schemes or by designing the houses / residential units to act as an acoustic screen for the gardens.

In our judgment it is therefore prudent in identifying the development land for the Eastern Villages to ensure that the mitigated site meets the requirements and guidelines for external noise.

For outdoor living areas during the day, the World Health Organisation Guidelines for Community Noise identify external daytime $LAeq_{16hr}$ noise limits of 50dBA for moderate annoyance and 55dBA for serious annoyance. We would regard the limiting value for development as being 55dBA $LAeq_{16hr}$ without the inclusion of further detailed mitigation design using the residential units themselves.

3. Method Of Analysis

3.1. ISO 9613

Using Mithra, a calibrated model was provided of the road noise sources to predict noise levels at the property facades and garden amenity spaces up to 300m from the A419 corridor. For this application, Mithra calculates the spread of noise according to ISO 9613. It also allows for different noise barrier designs to be incorporated and assessed acoustically. This enabled the optimum noise barrier design to be determined in terms of position, height, performance and type.

3.2. Do Nothing / Do Something

The noise impact assessment is carried out for current conditions for the traffic based on 2013 figures. In assessing the mitigation performance of the existing fences or of any potential new noise barriers, it will be necessary to determine if this performance is maintained into the future. For this a design year of 2028 was considered. In other words 15 years hence. It was therefore necessary to determine the impact to do nothing. In other words what would be the noise impact on residents behind the existing fences taking into account the build-up of traffic from 2013 to 2028 and the possible degradation in mitigation performance due to fence deterioration.

We would also need to determine the impact to do something. In other words to build new noise barriers to fill in the gaps on the west side and potentially to replace some of the existing fences by 2028 if this can be shown to be of benefit.

3.3. Timber Fence Degradation

In their Published Project Report PPR490 "The Acoustic Durability of Timber Barriers in England's Strategic Road Network" TRL, the Transport Research Laboratory undertook laboratory and on site acoustic testing of existing UK timber barriers. With regard to the testing of single skinned timber noise barriers they concluded:

"Overall, the results would suggest that for single-leaf timber reflective barriers, any degradation in acoustic performance occurs during the first 5 years after construction. Depending upon the initial performance, this decrease appears to be of the order of 4-7 dB"

Degradation in acoustic performance of 4-7 dB is a significant amount to lose and would normally be sufficient to render a barrier non-compliant against its original design performance specification. In assessing the performance of the existing single skinned timber barriers it was necessary to take this order of degradation into account.

Furthermore the existing upper fence at Commonhead was observed to already be in relatively poor condition and would be unlikely to maintain acoustic integrity for the next 15 years. For the 2028 do nothing model we have therefore assumed that it was no longer physically present. It has been queried as to whether this barrier was originally specified as a noise barrier. However if a functioning barrier is removed from this location in the noise model there is a significant loss of noise mitigation for the properties to the rear of the barrier. We therefore recommended that it be replaced with a durable low maintenance noise barrier in the near future.

4. Solar Noise Barrier Options

4.1. Noise Barrier Specification

This is a study for the feasibility of utilizing a solar noise barrier design for the A419. As part of this it is essential that the noise barrier element of the design is robustly specified to the current British and European Standard: BSEN 14388. This standard provide the means by which noise barrier products are CE Marked which is now a requirement for noise barriers on all European Highways.

It may be that it is not possible to find composite barriers that combine solar and acoustic properties that carry a CE Mark. We would recommend that in so far as noise barrier products are used, that they should be CE Marked. Noise barriers for this scheme could typically be of a metal, polymer or ceramic based construction. What is important is that they are low maintenance and meet the acoustic and structural performance specification.

4.2. Solar Design Options

Three separate noise barrier style options were considered for this scheme depending on the location and room available. For the gaps on the west side, the most appropriate location for a noise barrier would be close to the carriageway within the HA boundary. Whilst this remains the best location acoustically (closest to the source), for the Eastern Villages, the land is available to build outside the Highways boundary. This would carry with it less restriction of design and access.

Absorptive Barrier with Solar T-Piece

For barrier locations on highways land, an absorptive barrier with a solar T-Piece is considered. An example of this can be seen on the A13 in Switzerland. The solar T-piece (1-2metres) would be mounted on top of the barrier and angled for solar efficiency. The benefit of this design is that it is does not require much space. It does not however provide as much surface area for solar panelling as the solar bund or Brennar-style design.

Solar Bund

Where land is readily available, cladding a bund with solar paneling provides a practical and effective option. This would need to be high because the barrier is further from the noise source and is more suited to new developments where earth for the bund may be in ready supply. The bund acts as the noise barrier. The solar panels are acoustically reflective but at a typical angle of 35^{o} any incident traffic noise would be reflected over the houses opposite. The benefit of this design is the large surface area for solar paneling. In Freising near Munich there is an angled solar array next to the motorway that is partially mounted onto a bund and gives the same visual appearance roadside.

Brennar Solar Barrier

On the Austrian/Italian border there is a free standing solar noise barrier at Brennar/Brennaro. This barrier is fully clad with solar panels and angled at 60^{o} for the first 3.2 metres and then at 35^{o} for 1.6 metres. As such it again reflects incident noise over any houses opposite. The back of the barrier provides an insulating layer sufficient for the free standing structure to act as a noise barrier. Again the benefit of this design is the large surface area for solar paneling.

4.3. Choosing and Optimum Design

When designing a noise barrier the length and surface area is optimized so that no more than is necessary is built to meet the noise requirements. For solar power generation, the bigger surface area is better. Therefore the first step of the design is to ensure the noise barrier element provides the required acoustic performance and then to extend the solar barrier size to ensure optimum power generation and revenue.

For a number of the locations considered, the existing foliage and tree growth can ensure that sufficient solar power generation is just not practical or possible. In such locations, it is better to pursue the noise barrier option without the solar as the best solution.

5. Discussion of Results

5.1. Gaps on the Western Side

On consultation the expanse of existing foliage on the Western side of the A419 would make solar power generation impractical. It was therefore recommended to design for non-solar absorptive noise barriers for the gap locations at Liden Lagoon, Merlin Way, Watermead and Retingham Way.

As a result of the study, 3 metre high absorptive barriers were proposed for each of the 4 gap locations being 200 metres long at Liden Lagoon, 500 metres at Merlin Way, 600 metres at Watermead and 400 metres at Retingham Way, giving a total length of 1700 metres of new absorptive barriers for the Western side of the Swindon A419.

This would ensure that by 2028, no properties behind these barriers would exceed 68dBA $L10_{18hr}$ at the property façade, and of those most directly exposed, 70% would be below 60dBA $L10_{18hr}$

5.2. Eastern Villages Solar Noise Barrier

3m Solar T-Piece

The minimum frontage to the A419 of the Eastern Villages development land that will need protecting with a noise barrier is about 1.25 km. However in order to optimize solar power generation the length was increased to 2km in total.

A 3 m high Solar T-Piece Noise Barrier within the Highways boundary and close to the verge of the A419 would bring the 55dBA $LAeq_{16hr}$ contour considerably closer toward the carriageway. This would dramatically increase the area that can be developed for residential purposes by about

275,000sqm of the available land for the Eastern villages.

4.5m Solar Bund

Installing a 4.5 metre high solar bund just outside of the Highways boundary would not perform as efficiently as the T-Piece option but would still result in an increase in the area that can be developed for residential purposes by about 180,000sqm of the available land for the Eastern villages.

A further benefit of this option is the larger surface area for solar panelling on the bund and the fact that installation would be outside the HA boundary.

4m Brennar Style Solar Barrier

Installing a 4 metre high Brennar Style solar noise barrier just outside of the Highways boundary would have a greater efficiency than the bund resulting in an increase in the area that could be developed for residential purposes by about 230,000sqm of the available land for the Eastern villages). If the barrier height were increased to 5 metres, the performance would be similar to the T-Piece design.

A further benefit of this option is the larger surface area for solar paneling on the barrier and the fact that installation will be outside the HA boundary.

6. Conclusions

6.1. Overall Cost-Benefit of the Scheme

For the Western side, a total length of 1.7 km of 3m high absorptive noise barriers for Watermead, Merlin Way, Retingham Way and Liden Lagoon would cost under £ 700,000 to supply and install. The benefit would be to reduce the total number of properties currently over 60dBA LA1018r from 200 down to 60 and to ensure that no properties behind these barriers are receiving noise levels over 68dBA LA1018r even in 2028.

For the Eastern Villages, in terms of installed cost and the potential increase in development land, the Solar T-Piece noise barrier design would be the preferred option. However in terms of ongoing annual revenue from solar power the Solar Bund or the Brennar Style barrier would be preferred.

Since the Solar Bund and Brennar Style barrier are not on Highways land they would constitute the more likely design to proceed for budgetary purposes costing approximately £2.6 million and generating annually £140,000.

Taking the Noise Barriers at Watermead, Merlin Way, Retingham Way, Liden Lagoon and Eastern Villages Solar Barrier together, the overall cost to supply and install the solar noise barrier scheme would be approximately **£3.2 million**. However, with **£140,000** per annum generated through solar, the 25 year total income would be **£3.5 million** covering the costs of both the solar and traditional noise barriers along the A419.

6.2. M4 Wichelstowe

As part of the ongoing energy plan for Swindon, a further feasibility study will be carried out to determine the viability and acoustic/solar benefit of installing a solar noise scheme along the M4 at Wichelstowe. Being south facing, an assumed 3.5 km long solar bund scheme would cost in excess of £5.4 million and potentially generate around £260,000 per annum, paying for the whole scheme over approximately a 20 year time frame.

It would also benefit the council owned development bundles of Wichelstowe by increasing residential development potential and therefore land value in the same way as for the Eastern Villages scheme.